ing becomes displaced from the bottom of a timber ship, the worms get in, and work through, after them the water insinuates itself. Leaks and foundering are the next consequences in strictly natural series.

In one mass of obstructions hauled away from the beach of Morris Island, are 16 bars of T-iron rails, each 23 feet in length. So great was the weight of the mass that the bars to which the hawser was attached were bent to a curve of about 35°. The hawser, a new one of six inches circumference, was stretched out to only four inches. Fifty men were occupied four days in hauling out of the tide-water the mass I have described. Before the other obstructions can be removed the drifting sands will bury them, and they will be lost forever. The obstructions being removed by natural causes, nothing now prevents the taking of Charleston whenever the Admiral wills it."

PROGRESS OF ENGINEERING SCIENCE.

The above forms the text of an elaborate and able article in the *Quarterly Review*. From this we select several extracts which will be read with interest by all :—

Water-Pressure Engines.—Recently a new application of water power has been effected by the inventive genius of Sir W. Armstrong. He first applied it at Newcastle, where the general level of the town is very much above that of the wharves of the harbor, and the waterworks in consequence provided a very tall column of water at the lower levels. Of this he availed himself by applying the pressure so obtained to force a piston along a water-tight cylinder, and with a simple multiplying gear the cranes on the quays were made, by the mere turning of a cock, to raise any weight their construction could support. By applying the water power alternately on both sides of the piston, and acting on a cranked axle—as done in the steam engine—a water engine was next invented, capable of exerting any amount of power that could be obtained from the hight of the column of water and the amount of supply. When a sufficient head of water is available, or where the work is intermittent, this is certainly one of the most successful applications of water power yet invented. At Great Grimsby Dock, and at Birkenhead, pipes are laid under the pavement from a reservoir at the top of a tall tower, to every part of the dock premises. At the foot of every crane, under the piston of every hoist, at every dock gate, unseen and noiseless, the power lies dormant; but a woman's hand, applied to a small handle, will set in motion a force sufficient to raise a mass weighing fifty or one hundred tuns, either to place it in the hold of a ship, or deposit it in any spot within reach of the arms of the crane. With equal ease the gates of locks 100 feet in width are opened or shut and the smallest as well as the heaviest works of the dockyard done, without a stranger being able to perceive what it is that sets everything in motion.

As an accumulator of power, Bramah's hydraulic press surpasses anything that has yet been invented, and may be carried to any extent that the strength of the metal will stand. The presses which were used to raise the tubes of the Menai Bridge when worked by a 40-horse power engine, were capable of exerting a power equal to that of 14,200 horses, and raised one-half the tube, or 900 tuns, slowly but steadily, through the 100 feet at which they were to be placed above the level of the water.

Air-Pressure Engines.—The tunnel under Mont Cenis is to be rather more than seven miles and a half in length, and as it is one English mile below the summit of the mountain; no air-shafts could be sunk from above; and the first difficulty was to ventilate a cul-de-sac, that at one time, at least, must be nearly four miles in length. This has been accomplished most successfully by M. Someiller, the engineer, availing himself—on the Italian side—of a stream of water 80 feet above the mouth of the tunnel. This is used to force air into a chamber, where it is kept at a constant pressure of six atmospheres, by a stand-pipe 165 feet (50 meters) in hight. From this it is conveyed in pipes to the innermost end of the excavation, where it is set to work to bore holes in the face of the rock for blasting purposes. There are eight perforators, each of which sinks ten holes three feet deep in the face of the rock in six hours. It takes some time to dry each of these and to charge it with gunpowder; and it takes four hours to clear away the *debris* and to make all ready for commencing another set of perforations. So that practically only two sets are bored in twenty-four hours, and the progress is consequently 6 feet per day. At each blow on the head of the jumper a portion of the compressed air escapes, as steam does in a high-pressure engine. Its expansion is sufficient to cause a draft outwards, and keep the place perfectly ventilated; and even immediately after a blast, the tunnel is freed from the effects of the explosion very rapidly, and no inconvenience felt. By improvements in the machinery, the engineer hopes to bore one set of holes in eight hours; and as the more work it does the more air it blows off, not only will the work be expedited, but the ventilation improved by the more rapid working.

The Steam Engine.—Without doubt the invention of the steam engine is the greatest mechanical triumph which man has yet achieved. Although the invention of a practical engine is hardly more than eighty years old, and it is little more than half that time since its real value came to be appreciated, the mode in which engines have been multiplied and improved during the last forty years, and the thousand new purposes to which they have been and are daily being applied, is perhaps the most extraordinary fact in the industrial history of the world, It certainly is the one, the magnitude of whose results we are the least able to grasp. One of the greatest advantages of the steam engine, besides the power of placing it anywhere, is the wonderful flexibility with which it can adapt itself to almost any work it is set to perform. The difference between an elephant and a race-horse is not greater than between a Cornish pumping engine and an express locomotive. The perfection of the former arose from the necessity of importing every ounce of fuel to be used in Cornwall, and frequently of carrying it for miles over bad roads. This set engineers calculating how fuel could be saved, and with such success, that at one time a pound of coals did twice the quantity of work that it did elsewhere, though this difference is fast vanishing now. To any one accustomed to the noisy activity of most marine or manufacturing engines, nothing can be more remarkable than the sleepy quiet of Cornwall. The fire-bar area is so great, and the boiler arrangements so roomy and so carefully appropriate, that all the fuel and all the smoke are consumed, and none issues from the chimney. In the engine room nothing is seen but one great cylinder, hooped with wood, and looking more like a beer-vat than a part of an engine, and almost as cool to the touch. A few slender bright rods extend from the roof through the floor, and to these are attached some delicate bright handles, of rather fanciful forms, but these suffice to open and shut its valves and to regulate its expansion. As the stranger enters, all is quiet and at rest; no burst of smoke, no smell of oil, no escape of steam, and no noise; presently there is a click click among the handles, the great beam lazily raises itself and lifts 100 or 200 fathoms of heavy pit work some ten feet upward, and then as quietly drops it again into its place. Having done this giant's work it goes to sleep again for ten or twenty seconds, as the case may be, till called upon to make another effort. This it repeats at stated intervals during the whole twenty-four hours, week after week, or for months together, without rest or intermission.

Contrast this with the express engine, rushing past at a speed of fifty or sixty miles an hour, making 1,000 or 1,200 pulsations in a minute, consuming coals with reckless wastefulness, and casting its vital heat and life's blood to the four winds at each beat of its valves. Nothing that man has done comes so near to the creation of an animal as this—even the most unimaginative can hardly help drawing comparisons between the steam horse and his quadrupedal competitor. There is indeed more in the comparison than appears at first; especially when we see the monster fed with great spoonsful of cooked black vegetable food, from which it evolves its vital heat in its capacious lungs, which, after circulating through its tubular veins, is launched into the air with the waste products of combustion.

In this as in most things, the steam engine is strictly original, and, strange to say, no new principle has been invented since Watt left it, and no new form added which he did not at least foresee. The immense progress that has been made since his day has been due to the daily growing perfection of workmanship, and more perhaps to the careful adjustment of every part, and of every engine to the exact special work it has to perform. The progress is practically due to the knowledge which is obtained by the daily experience of those who watch the working of all these engines, from those which make three strokes in one minute, to those that make 1,000 in the same time, as well as all the intermediate grades between these two extremes, which are hourly performing every class of work under the most completely various circumstances.

There does not seem to be any theoretical limit to the size of a cylinder of a steam engine, or consequently to the power that may be given to it; but, practically, it is generally found more expedient to use two or more engines to do a given amount of work than to increase to any very great extent the power of one. Pumping engines with cylinders 100 inches in diameter and with 10 feet stroke, are common in Cornwall, and those used to drain the Haarlem Lake were 14 inches in diameter; and in the *Warrior* and *Achilles* the pair of engines are nominally 1,250 or 1,300 horse-power, but really work up to 5,000 or 6,000 horse-power. When more than this is wanted, it may be expedient to divide it, as was done in the *Great Eastern*, between two sets of engines; for it is not only the cylinder, but the crank shaft, and all the gear, that require to be increased in the same ratio. Although the power of our factories to produce the immense forgings requisite for these purposes has been increased tenfold within the last thirty or forty years and is daily increasing, there are inconveniences in dividing power, where there is room to do so, that will probably prevent any great increase in this direction.

The Cotton Manufacture.—In England it is calculated that, when the cotton manufacture is thriving, there are thirty millions of spindles constantly employed in spinning cotton alone, so that if every man, woman and child in the three kingdoms were to devote twelve hours a day to this occupation, they could not effect as much; and it would require another population of nearly equal extent to prepare the cotton for the spindles, and a very large number of persons to supply the place of the 300,000 power-looms that are employed to weave it, and to supplant all the mechanical appliances that finish it and fit it for the market. All this is required for cotton; but when we add to this the amount of power employed in spinning and weaving flax and wool, and all the different classes of fibers which we have enlisted in our service, the power employed in cotton alone sinks to a mere fraction.

Steamships.—Till the invention of the compass, long sea voyages were of course impossible, and large vessels were consequently not needed for commercial purposes; but the discovery of the uses of a keel, or something to enable a vessel to hold a wind, even if she could not beat to windward, was almost as important, for propulsion by oars must always have been very expensive and inefficient in large vessels. An immense impulse was also given to the improvement of vessels by the discovery of America, and of the passage round the Cape, and since then the progress has been rapid and steady; but it was not till propulsion by steam cleared the problem of all extraneous considerations of weatherlyness, steadiness and handiness in maneuvering, &c., that marine architects fairly grappled with the subject.

In order to explain the problem the shipwright has before him, it may be necessary to state that a vessel, for instance, of 1,500 tuns, 36 feet beam, 250 feet long, and with 20 feet raft, displaces 20 tuns of water for every foot she moves forward, and the question is what is she to do with this? If she heaps it up before her, as the old bluff-bowed vessels did, she has not only to climb over it, but she has wasted an enormous amount of power in lifting what she might have left lying. As every contractor knows, he is paid the same for wheeling stuff twenty yards forward as for raising it one yard high; and what the naval engineer seeks to do is to spread his displaced water laterally, evenly and flatly, over as large a surface as possible. The progress already made in this direction will be understood if we take, for instance, the resistance of a square box as our unit. By simply rounding off the corners, the power requisite to force the box through the water is diminished by one-third; by introducing such lines as were usual in the best ships thirty years ago, the resistance is lessened by twothirds. Whereas now, in consequence of the improved lines which are mainly due to the long scientific investigations of Mr. Scott Russell and his coadjutors, the resistance is only one-twelfth of that of the box first mentioned; and this fraction may before long be reduced to one-twentieth or even one-twenty-fourth. The consequence of this is, that twenty years ago engines of 500-horse power barely sufficed to drive a vessel of 1,000 tuns burthen ten knots through the water; the same engines would now propel a vessel of 1,500 tuns at least fourteen knots; and better results than this are being attained. Already twenty miles an hour has been reached, the Holyhead packets working steadily at that rate; and even an armed dispatch vessel has just left this country for China, which, with all her armament on board, can do as much, and that without any extraordinary exertion. Having reached this speed, we cannot long be content with less. Vessels must cross the Atlantic at the rate of 500 miles a day. It would be expensive to build a vessel to do this to-day, and it might beat some waste of power she would accomplish it; but day by day it is becoming less difficult, and before long it will be easy. Had the *Great Eastern* been built for speed alone, she could easily have accomplished this; but carrying power was her great object, and her calculated speed was 15 miles, which she accomplishes with singular evenness in rough weather as well as smooth. She has run 475 miles in twenty-four hours, but her average speed is about 360, or 15 miles per hour, or about the average speed of the best ocean steamers of the present day. This they accomplish easily, without the sacrifice of any of their qualities as sea-going vessels, while retaining the capability of accommodating a large number of passengers, and a considerable amount of cargo for a voyage of 3,000 miles—the distance (speaking in round numbers) of New York from Liverpool.

But it is not only in speed that such progress has been made, as vessels have increased in size in even a greater ratio. Thirty years ago 1,300 tuns was the measurement of our largest indiamen, and 2,000 tuns of a first-class line-of-battle ship. We were all astonished some ten years ago when we heard of the *Duke of Wellington* being launched, of 3,800 tuns; and the *Himalaya*, of 3,600, built since that time, was the largest merchant vessel the world had ever seen. Now our first-class iron-plated frigates measure at least 6,000 tuns. The *Great Eastern* is 691 feet long, 83 feet wide, and registers 18,914 tuns, though her real capacity is nearer 25,000 tuns, and the indicated power of paddle-wheel engines is equal to 3,600 horses, and that of her screw to 4,800, making together 8,400 horse power. If she has not obtained, commercially, the success that was anticipated, it is not that our engineers did not know how to design and build her, or how to furnish her with the requisite power, but simply that she was born before her time. The world is not yet ready for vessels of her size. Without disrespect to any one we may say that until vessels of very large size become more common than they are, and until nautical experience has been enlarged by the use of such ships, there cannot be captains capable, in the highest sense, of commanding, or sailors and engineers sufficiently educated to work so gigantic a machine.

[To be continued.]

Physiology of Swimming.—The medical authorities of the French army especially recommend that men inclined to disease of the chest should be made to swim. The following are the effects (which M. le Docteur Dulon attributes to swimming) on the organs of respiration:—A swimmer wishing to proceed from one place to another, is obliged to deploy his arms and legs to cut through the liquid, and beat the water with them to sustain himself. It is to the chest, as being the central point of sustentation, that every movement of the limbs responds. This irradiation of the movements of the chest, far from being hurtful to it, is beneficial; for, according to a sacred principle of physiology, the more an organ is put into action, the more vigor and aptitude it will gain to perform its functions. Applying this principle to nature, it will easily be perceived how the membranes of the chest of a swimmer acquire development—the pulmonary tissues firmness, tone and energy.

There is an American railway-car line in operation between the Place de la Concorde, Paris, and Sevres.

Correspondence

Heaton's System of Defensive Armor.

Messrs. Editors:—In your paper of Jan. 2d, you make some remarks on my system of defensive armor, which is illustrated in that paper; though not in such a way as to convey to a great majority of your readers a correct idea of it. You show a turret, supposed to be plated on two systems, one side on my system, and the other on the present or all iron system. But in my system you show what ought to be a thick iron plate, as wood, which makes the thing contradict itself; for if that was wood no bolts would be broken, and none of the disastrous effects of concussion which you show would be possible.

What I claim is, that wood cannot be made to communicate fracturing force to iron, indirectly; wood can be shot directly through iron, but not indirectly. For instance: A shot strikes fairly against the side of a turret composed of all iron, the ball does not go through, and, from an outward view no serious damage is inflicted, a dent, perhaps two inches deep, being the only apparent injury. But to see the real extent of the damage you must look inside the turret, when you will find a bulge, which will be in size just in proportion to the size of the shot and the thickness of the turret, every plate from the point of the shots impact communicating the force to the next one to it, until the inside plates which are furthest from the shot and which would be thought by some to be least liable to injury, are injured the most; being strained beyond endurance they crack and burst open, breaking the bolts and communicating the force of the shot to the inmates, often more seriously than if the shot actually entered directly; a bolt-head being just about as likely to "put a man out of the fight," as a ten or fifteen inch shot, if it only hit him right. The object of my system is to "take up" or destroy the first or maximum force of the shot, with a material of softer nature than iron; which material shall, in so "taking up" or destroying the force of the shot, communicate no fracturing force to the real or "main armor," which is held in reserve and not opposed directly to the action of the shot. Is a ship plated to save the ship or the inmates from injury? Can a shot be thrown against the sides of an iron-clad structure with sufficient force to smash the shot to pieces, without injuring the surface against which it is broken? It cannot, I think, no matter how heavily plated, within reason. If it is injured, in order to keep the ship shot-proof, it must be repaired: which is the most readily and cheaply repaired, iron or wood? I claim that the wood I use, in addition to actually saving the "iron armor" from serious injury, takes the damage which must be received in arresting shot suddenly, and is easily replaced. Wood may be forced through iron, or a soft substance through a harder one, by a sustained power or a continued application of force; but not by a cannon ball, because it is not a "continued application of force." It is simply weight and impetus—the result of force, and the momentary application of it—but not the continued application of it; and by no such means as this can a soft substance be forced through, or made to communicate fracturing force to a harder one; because the soft substance must first be rendered as dense or hard as the harder one before it can either injure it or communicate injury to it. And in this compression or densifying of the soft substance the force of the shot is exhausted or "taken up," or so much so without being communicated to the iron as to allow of its being arrested, without any serious injury to the main armor, and without producing that shock or concussion which is the cause of breaking bolts. Wood may be shot directly through iron, because here you have its weight and velocity to arrest; but it cannot be indirectly forced through a harder substance than itself.

Chas. W. S. Heaton.

New York Dec. 29, 1863.

[Since publishing the article referred to by our correspondent, we are in receipt of the official report from the Ordnance Bureau, of some experiments made with Heaton's target, from which it seems that his theory of construction is found wanting in practice. The official report will be published with illustrations, in the next number of the journal.—Eds.

Further Illustrations of the Electric Wave.

Messrs. Editors:—In my first article on the Electric Wave, there were points not sufficiently elucidated, and one or two mistakes unnoticed were printed. The latter I will now correct, and the former explain more fully.

When I say "The electric current does not run in a line of narrow limits; neither does it run in a straight line," I mean no more than to say that it runs just as a cylinder of two feet diamater runs, when turned by a crank and pushed longitudinally at the same time. We turn from the left to the right. So rotates or turns also the electric current or wave—from the left to the right. This law, as it relates to the electric current, is universal. We see that the cylinder turns at its remote end simultaneously with its turning at the crank end. So, likewise, is the turning or revolving of the electric wave. In regard to the wave, however, if the line of its motion be extended to a great distance, the motion of the wave at its terminus is not *precisely* simultaneous with its motion at the commencement. This is owing to the obstacles it has to overcome in its long passage, owing to the imperfect conducting properties of the intervening media along which it has to pass.

While the electric wave is thus rotating, it generates at its central line of motion a current at a right angle with its motion; and this is magnetism. This magnetic force or current does not rotate, but runs in a direct course from one of its poles to the other, in a line the motion of which commences with that of the electric wave. This magnetic force or current is very strikingly exemplified in the helices of the ordinary electro-magnetic machines, where the iron wire that is introduced into them becomes powerfully magnetic, with its north and south pole.

Besides this rotary motion, the electric wave has also a lineal motion; that is, it moves directly forward simultaneously with its rotation; this constitutes a spiral motion.

There is something sublime in contemplating this wonderful force. In it there is found the epitome of the universe. Its rotary and lineal motions represent the motions of the heavenly bodies on their own axis, as well as their orbitual motions; the one confined to its own center, and the other rushing from it.

Electricity in motion begets magnetism; and magnetism in motion begets electricity. The two elements, although so intimately related to each other, are, nevertheless, totally distinct in their powers. Glass offers an insurmountable obstacle to the transmission through it of electricity; while magnetism passes through without the least resistance. The passage of electricity is instantaneous, leaving no traces behind of its presence. Magnetism, on the contrary, on certain metals, such as steel, remains in full force. Electricity gives, but loses while it gives; but, wonderful as it may seem, magnetism gives and loses nothing. With one magnet we may make a thousand, without its losing the least of its magnetic power. It seems to be a God-like power. "God," as we read, "created man in his own image." Gen. i. 27. Yet God is the same he was before man was created, so the magnet remains the same after making other magnets. It is, doubtlessly, these two great principles that sustain the universe, and impart and regulate all its motions.

Samuel B. Smith.

Errata.—In my communication on the Electric Wave, which appeared in the Scientific American, Dec. 19th, 1863, the types make me say, "The electric wave extends twelve miles from its line of motion;" for *miles* read *inches*,—which is quite a difference.

A Bald Head.

Messrs. Editors:—I am only 23 years of age, and during the past twelve months the hair on the top of my head has become very thin and continues to get thinner; so much so that I fear ere long I shall, like Cesar, wear my wreath of laurels (a wig, I mean,) to conceal my baldness. Please be so kind as to inform me, through the columns of your much-esteemed journal, of the best remedy to make my hair grow again.

J. M. J.

[We really sympathize with our correspondent in his affliction, but we fear that there is no help for his case. One of us has a head as bare as a pumpkin,